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**The value of orthodontics: Do parents' willingness to pay values reflect the IOTN?**

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**Knowledge Transfer Statement**

The results of this study can be used by dental policy makers to determine how much resource should be allocated to orthodontic services for different malocclusions. They can also inform clinicians about the relative demand for treating different malocclusions which may aid shared decision making.

**Abstract**

***Introduction***

Given the limited evidence about the benefits of orthodontic treatment, many health care systems have rationed access to orthodontic care with the Index of Orthodontic Treatment Need (IOTN) being one tool used to attempt to allocate resources based on need. However, it is not clear whether patient and public valuations of different levels of need (as described by the IOTN) reflect the resource allocation decisions. The aim of this project was therefore to determine the values parents placed on correction of malocclusions at different IOTN levels using the willingness to pay (WTP) technique.

***Method***

401 parents of children attending hospital-based orthodontic clinics in the North of England were recruited to complete a questionnaire eliciting WTP for the correction of seven malocclusions with different IOTN scores. In addition demographic and orthodontic history characteristics were collected. Results were analysed with appropriate pairwise significance tests and regression.

***Results***

A significant difference in WTP was noted between all the possible pairs of malocclusions with the exception of overjets with moderate versus great need of treatments. At moderate levels, correction of crowding was valued less than overjet but this was reversed at great need levels. Very little of the variance in WTP was explained by the variables collected. When looking at factors affecting percentage difference between values for different pairs of malocclusions, in general, no factors predicted the magnitude of difference.

***Conclusion***

Median valuations for correction of malocclusions vary significantly for different levels of need (as judged by IOTN), with increasing levels of need generating higher values. However, there was a limited effect of demographic or orthodontic characteristics on the magnitude of percentage difference in values for correcting malocclusions different levels of need.

**Introduction**

There has been much debate in the literature about the value of orthodontic treatment (Benson et al. 2015). Effects on clinical aspects of dental health are not clear and the psycho-social benefits are varied and unpredictable with only low quality evidence to support them (Javidi et al. 2017). This has led to questions being raised about the provision of such treatment in fully or partially publically funded health systems (e.g. Audit Commission 2011). In some cases, the response has been to ration the treatment based on measures of need or sometimes on other factors. In some systems, the Index of Orthodontic Treatment Need (IOTN) is used to ration treatment (de Oliveira 2003). This index comprises two components: a dental health component (DHC) and an aesthetic component (AC). The DHC assesses various attributes of malocclusion (hypodontia or impaction, overjet,

crossbites, crowding and overbite) for their severity with the most severe attribute determining a score between 1 (no need for treatment) and 5 (very great need for treatment). The AC compares the patient's malocclusion to a set of 10 photographs with decreasing aesthetics, with the score between 1 (ideal occlusion) and 10 (least aesthetic) (Brook and Shaw 1989). In the NHS in England and Wales, patients with a DHC of 4 or 5 or those with a DHC of 3 plus an AC of 6 or above are eligible for treatment (NHS England 2015).

One important factor that should be borne in mind when making decisions about allocation of health system resources to any particular area is the value that the public and patients (and their parents/carers in the case of children) place on the treatment (Mitton and Donaldson 2001). It is not clear in the example of the NHS in England and Wales, whether the IOTN based rationing reflects either public or patient values of the treatment.

One method of eliciting values for health care is to use contingent valuation in the form of willingness to pay (WTP)(Donaldson and Shackley 1997). In this technique, frequently used in the discipline of economics, participants are given a scenario (for example, a description of a course of orthodontic treatment to correct a specific malocclusion) and are then asked the maximum they would be willing to pay to secure the treatment. There are various possible designs of the elicitation task in order to help the participant ascertain their value whilst minimising the problems associated with stating hypothetical values and with determining value rather than price or cost (Olsen and Smith 2001).

The aim of this study is to determine the values parents place on orthodontic treatment to correct different malocclusions described as having different levels of need by the IOTN from a UK perspective.

## Methods

### *Study Design*

A cross-sectional willingness to pay elicitation using a self-completion questionnaire was undertaken in all three hospitals that provide orthodontic services in the North East and North Cumbria region of England. The study had ethical approval from the NHS Wales Research and Ethics Committee 6 (reference 14/WA/1140).

### *Questionnaire design and WTP elicitation*

The questionnaire comprised three sections; a clinical record of IOTN; demographic and dental history details; WTP elicitation for different scenarios. The dental health and aesthetic component scores of the IOTN for the parent's child and their treatment stage (pre-, mid-, or post-active treatment) were completed by the treating orthodontist from the child's patient record of their initial orthodontic assessment. The parent completed demographic and dental history information about themselves and their child including gender, age, income, postcode (for determination of index of multiple deprivation), qualification level, employment details (for determination of socio-economic status), experience of and desire for orthodontics as well as satisfaction with alignment of teeth. These questions were based on standardised national questions where possible (Office for National Statistics 2017).

For the WTP elicitation, an ex-post user perspective was taken (i.e. participants were asked to place themselves in the hypothetical situation that they had the malocclusion described and were seeking treatment for it) which was appropriate given the elective nature of the intervention. Participants were presented with a series of standardised intra and extra-oral (cropped to show mouth only)

photographs (example of one malocclusion shown in Figure 1) representing the following malocclusions:

- "ideal" well aligned class I occlusion
- IOTN 2d (crowding with contact point displacement 1 to 2mm),
- IOTN 3d (crowding with contact point displacement 2 to 4mm),
- IOTN 3a (overjet of between 3.5 and 6mm plus incompetent lips),
- IOTN 4d (crowding with contact point displacement over 4mm),
- IOTN 4a (overjet of between 6-9mm)
- IOTN 5a (overjet of greater than 9mm but well aligned)
- IOTN 5a with crowding (overjet of greater than 9mm with crowding with contact point displacement of over 4mm)

FIGURE 1 HERE

Participants were then asked, for each malocclusion, the maximum they would be willing to pay to correct this to the "ideal" occlusion with a course of orthodontic treatment lasting 2 years involving visits every six weeks to the orthodontist for adjustment of the brace. Risks of decalcification and temporary pain or discomfort were also outlined. The script for the WTP task encouraged realistic, budget constrained responses, as well as emphasising the fact that value rather than price or cost were of interest and that the exercise was hypothetical. The actual values were elicited using a payment card method (Smith 2006) with values of £0, £50, £100, £250, £500, £750, £1000, £1500, £2000, £2500, £3000, £4000, £5000, £6000, £8000 and £10000 included. There was also an option for more than £10 000, for which participants were asked to write in the value. Where participants gave a zero value, a standard series of follow up questions (Ryan 2004) were asked to determine if the zero value was a protest response or a true lack of value. The questionnaire and scenarios were initially developed by the research team and then refined through a focus group of 10 orthodontists and finally through piloting with parents of children undergoing orthodontics.

***Sample***

The target population were parents of children being seen for orthodontic appointments in the North of England between October 2014 and June 2015. The sample were recruited from 3 hospital-based orthodontic units in the North of England (Newcastle Dental Hospital; Cumberland Infirmary, Carlisle; James Cook University Hospital, Middlesbrough). A required sample size of 400 was calculated based on an Events per Variable approach assuming a 20 variable model for sub-groups consisting of half the sample (Peduzzi et al. 1996) The sub-groups originally intended for analysis were post-orthodontic versus pre- and mid-orthodontics, but given the inequality in recruitment these analyses were not possible.

Parents/carers of patients were considered for inclusion if they could read/write in English and the patient was between 10-17 years old. Parents of children with specific developmental conditions (severe craniofacial anomalies, severe hypodontia and cleft lip and palate) were excluded. Participants were approached using a convenience sampling method (for practical reasons) by orthodontic specialists and specialty trainees, given information about the study, consented and then they completed the questionnaire during the child's orthodontic appointment. Recruitment procedures were the same in all three centres.

***Analysis***

Data were entered into STATA 11 (StataCorp 2009) and validation consisted of performing rationality and consistency tests on the whole sample. Analysis included descriptive statistics, appropriate pairwise tests to determine significance of difference in WTP between IOTN scenarios and regression analyses to control for demographic and dental variables and determine the factors predicting WTP values and also factors predicting difference in WTP between scenarios. For the regression, multi-level categorical variables (IMD, income, qualification and socio-economic status) were dummied to provide dichotomous variables. Tobit models were used for investigation of factors affecting WTP due to censoring of values at zero. The best model was chosen based on backwards stepwise elimination using Bayesian Information Criterion (BIC) to select the best model.

Relative difference in willingness to pay was calculated as a percentage between different scenarios and factors affecting this were investigated econometrically using appropriately fitted regression models. The best fitting models were chosen based on backwards stepwise elimination using adjusted $r^2$ to select the best fitting model.

**Results**

The final sample recruited were 401 parents/carers. The demographic characteristics of the sample are shown in Table 1. The sample included equal representation of all income bands, deprivation quintiles, qualification levels and socio-economic status levels.

*TABLE 1 HERE*

Median WTP values for each of the IOTN scenarios are shown in Table 2 alongside interquartile ranges. In addition, missing data and responses classified as protest zeros and therefore excluded from analysis are shown. A Skillings-Mack test indicated that there were significant differences between WTP values for different IOTN scenarios. Multiple Wilcoxon signed rank tests were therefore conducted with a Bonferroni correction (indicating $p<0.002$ would be significant) and are reported in Table 3, showing significant differences between all scenarios with the exception of 3a versus 4a.

TABLE 2 HERE

TABLE 3 HERE

Factors affecting WTP were studied using the values for WTP 5a + crowding, as the scenario with the largest median and variance. All collected demographic and orthodontic experience variables were included in the initial model. These were eliminated in a backwards stepwise fashion and the best fitting model (judged using BIC) is shown in Table 4. The pseudo $r^2$ for this model was 0.0068 and included 302 participants.

*TABLE 4 HERE*

When investigating factors affecting difference between scenarios, no model was significant for percentage difference between WTP for 4a and 4d (i.e. difference between overjet and crowding), 3d and 4d (i.e. severity of crowding at the margin of NHS eligibility), 2d and 4d (i.e. greater difference in severity of crowding) or 3a and 4a (i.e. severity of overjet at the margin of NHS eligibility). Potential variables included were recruitment centre, treatment stage, gender of participant, gender of participant's child, deprivation, income, qualification level, socio-economic

status, whether participant is happy with alignment of child's teeth, whether participant is happy with alignment of own teeth and whether any siblings of participant's child have had orthodontic treatment. Therefore, as the models were not significant, none of these had any significant effect on percentage difference in WTP for the four differences analysed. However, when percentage difference between WTP for 3a and 5a (i.e. severity of overjet at the extremes of NHS eligibility) was modelled, the best fitting model showed that having a lower socio-economic status meant the percentage difference was significantly smaller and being recruited at one centre (Newcastle) also meant that difference was significantly smaller. The model however, had a poor fit overall with an adjusted $r^2$ of 0.0239, meaning that most of the difference was not explained by the variables used.

**Discussion**

The study showed that there was a significant difference between WTP to treat almost all of the different malocclusions investigated in a sample of parents of current, former and potential orthodontic patients. However, the relative magnitude of the difference was unpredictable using the demographic and orthodontic history variables collected in the study. The results also indicate that there is a substantial variance in WTP values across the sample. The regression analysis on factors affecting WTP undertaken showed that very little of the variance was explicable using the variables collected here (reflected in the very small pseudo $r^2$ value). The absolute WTP values are for all but the 5a + crowding scenario likely to be less than the private market rate for a course of orthodontic treatment (anecdotally from around £2000 in the region where the study was undertaken) and equally are less than the mean value that state funded orthodontists are paid to undertake a course of treatment (approximately £1200) (NHS England 2015).

The values are potentially of great use to decision makers in allocating funding to treatment either by use in implicit or explicit (such as priority budgeting marginal analysis) (Mitton and Donaldson 2001) resource allocation decisions or when combined with cost in a cost benefit analysis (Donaldson and Shackley 1997). The fact that variance is so large and unpredictable means that policy makers have a more difficult task, given that for many in the sample, orthodontics is highly valued suggesting that the argument for allocating resources to orthodontics would be strong whereas for many others, their low valuations suggest the resource allocation argument would be weak. In terms of the specific factors, education has been shown to be an influencing factor in some dental studies (Leung and McGrath 2010; Tianviwat et al. 2008) but not in others (Augusti et al. 2013; Birch et al. 2004; Matthews et al. 2002). The influence of centre of recruitment irrespective of other demographic or orthodontic variables (as these were essentially controlled for by undertaking the regression) is surprising. The three centres studied and their orthodontic referral catchment areas are all different in some ways but none of these differences would logically seem to affect orthodontic valuations. The only possible explanation that might explain this is the availability of orthodontic services and the mix of state and private funded orthodontics accessible to the populations around these centres. It is also important to remember that there may have been other variables not measured here that may have had an influence on WTP. One important example is healthcare literacy and it is important that future studies of WTP in orthodontics consider this.

In addition to this, this particular study is of use in showing how a clinical measure of need (IOTN) matches with demand, with the results indicating that, in general, increasing need is reflected by increasing valuation but interestingly that correction of moderate overjets (3a) is valued more than correction of moderate crowding (3d) but the reverse is true at the great need level (4a and 4d). It is interesting to note that there was no difference detected between 3a and 4a. There is an argument that it is difficult to see differences in overjet, although the photographs used in this study did have

a visible difference. It may be that there is a certain threshold over which overjet becomes significantly valued and below this, it is not.

The main limitation of the study is the generalisability of the findings and the utility of these values to decision makers driven by the sampling strategy. Firstly, the sample consists of parents of children who are current, former and potential orthodontic patients. When using economic preference based values in resource allocation decisions, there is debate as to whether current/former patients using the actual intervention should provide values as they will have a greater understanding of what is being valued versus the funders of the health service in which the intervention is provided (e.g. for the NHS, as a publically funded system, the general public) as it is their money which is being allocated (Whitehead and Ali 2010). In general, it would seem that the funders of the service should provide values and so this study may be of limited use to decision makers. In addition, the sampling strategy did not attempt to ensure representativeness either of parents of users of the orthodontic service or the general population. However, there was good representation at all levels in the variables collected. Although decision makers might find a more representative sample useful, this data could still be used, providing the decision makers understood the characteristics of the group responding.

There may have been internal limitations in terms of the design of the WTP task. WTP elicitation often suffers from problems such as hypothetical bias (as the exercise is hypothetical, participants may not fully engage and give true values), anchoring (values given tend to anchor around existing perceptions of price or other external cues), range bias (participants tend to select a mid-point within the range given) (Carson 2000). It is interesting to note that values were actually substantially lower than the current market rates described earlier and so anchoring may not have been a major problem. In addition, participants can only value the scenario as it presented and incomplete scenarios will lead to incomplete valuations. The use of a range of photographic views alongside relevant text based descriptions ensured the scenario was realistic but inevitably, more information can always be given. It should also be remembered that the "outcome" photograph shown was of an ideal result and in some cases the actual result may not be as good as that shown. The values given therefore are for the best possible orthodontic treatment. In addition, the scenario presentation may have meant that participants were not fully aware of the functional impacts of orthodontic malocclusion, as the photographs were the key element and these generally only provide an aesthetic perspective. Finally, the elicitation script and bidding card format tried to minimise hypothetical and range bias and anchoring. However, these potential problems should be borne in mind when the results are considered.

Very little work has been undertaken using economic preference based measures in orthodontics despite this being an area of health care where there is controversy about its value in health systems. Other work undertaken has mainly focused on more specialised areas of orthodontics, in particular orthognathic surgery (Cunningham and Hunt 2000) or particular technical aspects e.g. appliance type (Rosvall et al. 2009). The WTP values in both studies were higher than those found here but this is likely to be because orthognathic cases are more severe and Rosvall et al. undertook their study in a different type of healthcare system. The wide variance and unpredictability of values does fit with other WTP studies in dentistry (Leung and McGrath 2010; Vernazza et al. 2015a; Vernazza et al. 2015b).

**Conclusion**

Valuations by patient's parents for treating different orthodontic malocclusions differed significantly by their rating on the IOTN scale. An increase in the severity of need (as judged by the IOTN) in either crowding or overjet led to an increase in WTP. However, correction of crowding was valued less than correction of overjet at moderate levels of need with the reverse being true at great levels

of need. There was considerable variance in the values and this variance as well as the scale of differences were not predicted by demographic or orthodontic variables.

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**Legends**

Figure 1 Example of photographs used to illustrate malocclusions (IOTN 3a in this case)

Table 1 Demographic and orthodontic status for sample

Table 2 Median WTP values for different IOTN scenarios (n=401)

Table 3 p values for Wilcoxon signed rank tests of significance of difference of WTP between IOTN scenarios

Table 4 tobit regression model to explain variation in WTP

Figure 1 Example of photographs used to illustrate malocclusions (IOTN 3a in this case)

| Variable | Category | Frequency (n=401) | Percent |
|---|---|---|---|
| **Treatment Stage** | Pre-active treatment (assessment or review) | 186 | 46.38 |
| | Mid-active treatment | 178 | 44.39 |
| | Post-active treatment (in retention) | 37 | 9.23 |
| **Gender of parent** | Female | 329 | 82.04 |
| **Gender of child** | Female | 254 | 63.34 |
| **English Index of Multiple Deprivation Quintile** | 1 (least deprived) | 64 | 15.96 |
| | 2 | 79 | 19.70 |
| | 3 | 79 | 19.70 |
| | 4 | 93 | 23.19 |
| | 5 | 67 | 16.71 |
| | *Missing* | *19* | *4.74* |
| **Annual gross household income** | £0-£5,199 | 4 | 1.00 |
| | £5,200-£10,399 | 27 | 6.73 |
| | £10,400-£15,599 | 42 | 10.47 |
| | £15,600-£20,799 | 32 | 7.98 |
| | £20,800-£25,999 | 38 | 9.48 |
| | £26,000-£31,199 | 45 | 11.22 |
| | £31,200-£36,399 | 31 | 7.73 |
| | £36,400-£51,999 | 71 | 17.71 |
| | £52,000+ | 100 | 24.94 |
| | *Missing* | *11* | *2.74* |
| **Highest qualification (UK terms)** | GCSE (grade D-G) or equivalent | 44 | 10.97 |
| | GCSE (grade A-C) or equivalent | 98 | 24.44 |
| | A level or equivalent | 103 | 25.69 |
| | Bachelor's degree or equivalent | 85 | 21.20 |
| | Higher degree or equivalent | 31 | 7.73 |
| | *Unsure* | *30* | *7.48* |
| | *Missing* | *10* | *2.49* |
| **Socio-economic status (NSSEC)** | 1 (highest) | 191 | 47.63 |
| | 2 | 75 | 18.70 |

| | | | |
|---|---|---|---|
| | 3 | 30 | 7.48 |
| | 4 | 32 | 7.98 |
| | 5 (lowest) | 54 | 13.47 |
| | *Missing/Not calculable* | *19* | *4.74* |
| **Were you happy with the alignment of your child's teeth before treatment?** | Yes | 79 | 19.70 |
| | *Missing* | *1* | *0.25* |
| **Have any siblings had orthodontic treatment?** | Yes | 110 | 27.43 |
| **Are you happy with the alignment of your own teeth?** | Yes | 265 | 66.08 |
| | *Missing* | *2* | *0.50* |

**Table 1 Demographic and orthodontic status for sample**

| IOTN of Scenario | Proportion missing responses (%) | Proportion protest zero responses (%) | Median WTP (£) | Inter-quartile range |
|---|---|---|---|---|
| 2d (mild crowding) | 1.5 | 5.2 | 100 | 500 |
| 3d (moderate crowding) | 1.0 | 5.5 | 250 | 700 |
| 3a (overjet <3.5mm) | 0.7 | 5.2 | 500 | 900 |
| 4d (severe crowding) | 1.2 | 5.2 | 750 | 1250 |
| 4a (overjet <6mm) | 1.7 | 6.0 | 500 | 900 |
| 5a (overjet <9mm) | 0.7 | 6.0 | 750 | 1750 |
| 5a + crowding | 1.2 | 6.0 | 2000 | 3250 |

**Table 3 Median WTP values for different IOTN scenarios (n=401)**

| | 2d | 3d | 3a | 4d | 4a | 5a | 5a + crowding |
|---|---|---|---|---|---|---|---|
| **2d (mild crowding)** | | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 |
| **3d (moderate crowding)** | | | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 |
| **3a (overjet <3.5mm)** | | | | <0.0001 | 0.1659 | <0.0001 | <0.0001 |
| **4d (severe crowding)** | | | | | <0.0001 | <0.0001 | <0.0001 |
| **4a (overjet <6mm)** | | | | | | <0.0001 | <0.0001 |
| **5a (overjet <9mm)** | | | | | | | <0.0001 |
| **5a + crowding** | | | | | | | |

**Table 3 p values for Wilcoxon signed rank tests of significance of difference of WTP between IOTN scenarios**

| | Coefficient | Standard Error | t | p>t | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower bound | Upper bound |
| Centre: Newcastle | −772.51 | 424.34 | −1.82 | 0.070 | −1607.71 | 62.68 |
| Centre: Carlisle | −1105.55 | 436.78 | −2.53 | 0.012 | −1965.21 | −245.88 |
| Child is pre-orthodontics | −478.68 | 703.88 | −0.68 | 0.497 | −1864.06 | 906.70 |
| Child is mid-orthodontics | 382.84 | 656.73 | 0.58 | 0.560 | −909.74 | 1675.42 |
| High Index of Multiple Deprivation | −447.12 | 376.00 | −1.19 | 0.235 | −1187.17 | 292.93 |
| High income | 601.34 | 394.47 | 1.52 | 0.128 | −175.06 | 1377.74 |
| High educational qualification | 932.57 | 416.82 | 2.24 | 0.026 | 112.18 | 1752.96 |
| High socio-economic status | −54.34 | 416.80 | −0.13 | 0.896 | −874.69 | 766.01 |
| Happy with alignment child's teeth | 431.45 | 452.27 | 0.95 | 0.341 | −458.71 | 1321.61 |
| Sibling has orthodontic experience | −114.62 | 395.73 | −0.29 | 0.772 | −893.50 | 664.26 |
| Happy with alignment own teeth | 251.82 | 374.28 | 0.67 | 0.502 | −484.84 | 988.49 |
| Age of respondent (continuous) | 33.92 | 31.033 | 1.09 | 0.275 | −27.16 | 95.00 |
| Age of child (continuous) | −53.51 | 110.31 | −0.49 | 0.628 | −270.63 | 163.61 |
| Constant | 2154.20 | 2155.58 | 1.00 | 0.318 | −2088.42 | 6396.83 |
| /sigma | 2903.37 | 121.65 | | | 2663.95 | 3142.79 |

**Table 4 tobit regression model to explain variation in WTP**